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Relating Fires Affect On Forest Succession and Forest's Effect on Fire Severity in One Burned and Unburned Environment

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RELATING FIRES AFFECT ON FOREST SUCCESSSION AND FOREST'S EFFECT ON FIRE SEVERITY IN ONE BURNED AND UNBURNED ENVIRONMENT

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Abstract

Wildfires are a natural part of many forest ecosystems and play a vital role in maintaining their health. Wildfires can have a critical influence on a landscapes plant community through their relative frequency, seasonality, and severity. One of the most heavily influenced regions by wildfire disturbance is the Klamath Mountain region of California. I looked at the affect a wildfires severity had on the Whiskey creek valley within the Whiskeytown National Recreation Area. 8 tree species and 4 flower species were examined on both the burned and unburned regions within this valley nearly a year after the wildfire (May 17-23 2009) was completed. I saw differences in the vegetation diversity, density, and ground cover on both sides of the Whiskey creek valley. The California Live Oak was the most dominant species found throughout the unburned region, but was not present on the burned region. The most abundant species throughout burned region was the Scrub Oak, which only appeared after the wildfire and was not present in the unburned area. I noticed that from changes in tree species diversity and major alterations in ground cover between both regions there was a shift to an earlier successionary period.

Introduction

Wildfires are a continuing natural process that affects millions of acres every year. These natural fires can be devastating, and capable of clearing all visible life from a landscape. Because of the power and unpredictability of wildfires, the U.S. Forest Service (USFS) had for many years had heavily suppressed wildfires in order to completely protect federal land from burning. Although this practice seemed effective for many years, the heavy buildup of woody fuels loads from altered burn cycles created large scale wildfire disasters such as the Yellowstone fire of 1988 (Romme, 1989). These events brought about new wildfire management policies and prompted ecologists to study more closely fires affect on forest succession in the western United States.

Today the USFS and other land management agencies are beginning to view these wildfires in a very different manner. The new management techniques for controlling wildfires focus heavily on reducing the damage created and the role of fire in natural resource management. This is the role that fire plays which allows for the healthy regeneration of an ecosystem's biodiversity in a post burn environment.

One of the best regions to look at the after effects of a wildfire is in the Klamath Mountain region of northern California. Generally this region can be characterized by warm dry summers, and cool moist winters. Although climate does play a pivotal role in when an ecosystem will burn, other landscape factors must be assessed. The diverse landscapes of California provide many different factors to consider such as elevation changes, coastal influences, vegetation differences, and topography. These important factors essentially dictate the different fires seasons that are present throughout the year, and where they are found (Sugihara, 2006).

This region is characterized by diverse western forest vegetation such as Live and Black Oak, Shrubland Manzanitas, Douglas fir, and Ponderosa pine (Sugihara, 2006). These plant species in the Klamath Region re-establish themselves very effectively; however their distribution prior to the fire may not match post burn distribution. The ability to predict the post burn vegetative diversity in this environment may allow for more effective and ecologically beneficial methods of fire management.

In order to look at the how fire affects the plant diversity in the Klamath mountain region, fire must be analyzed in three different aspects. A fire's regime attributes are essentially defined by their seasonality, frequency, and severity (Sugihara, 2006). Together these important attributes define the type of fire regime that the specific fire will fall into, and the effect it will have on the plant communities. However, before that can be determined, each of the three defining features of a wildfire must be assessed.

The seasonality of which a fire returns to a specific area is an attribute that is assessed on a temporal scale. These temporal attributes of a fire's seasonality are not with out change, the pattern by which these fires occur can change with the alteration of a landscapes climate, fuel, and species composition (Pyne, 1996). Any change in these landscape areas or temporal patterns will commonly change all other factors.

Another important aspect of fire ecology is the frequency by which fires affect the landscape. The length of time between fires on a particular area of land, or fire return interval, is the other way that fire frequency is defined. The frequency that a fire returns to an area is critical for the plant species able to survive and thrive in a particular landscape (Pyne, 1996). Certain plant species require specific fire return intervals. A specific species may not be able to survive if a fire occurs too frequently, too late, or too infrequent for it to complete its life cycle. The frequency by which a fire occurs can be, for instance, the difference between oak woodlands changing into a Douglas fir forest, which is far more tolerant of wider fire return intervals.

The last of the three key components of fire regime attributes is the severity that a fire will affect a landscape. Fire severity is measured by the magnitude of effect a fire has on an environment. The magnitude by which fire severity is measured can be directly affected by a multitude of ecosystem components, including vegetation, soil, watersheds, topography, and wildlife habitat (Pyne, 1996). The measure of a fire's severity is not simply the intensity at which it burns, but also the factors of residence time and current moisture conditions.

With an understanding of a fire regimes influence on how an ecosystem deals with fire, it is possible to address the responses that dominant plant communities in the Klamath region will have to fire. This specific bioregion in California can be examined by looking at its lower to mid montane zones. These elevation zones are comprised of multiple plant species that respond to fire in very different ways (Keely, 2002). In the lower montane region species such as the California black oak, California Live Oak, and Whiteleaf manzanita are prevalent. These vegetative communities are generally accustomed to fires of high severity occurring every 50 to 100 years, which allows for the development of moderately open forests over the next century (Romme, 2003). In the mid montane region, species such as the Whiteleaf manzanita, Knobcone pine, Grey pine, Ponderosa pine, and Douglas fir are the most prominent. This region is influenced more by fires of moderate severity, which allows the species to reestablish dense stands over a shorter time period of 20 to 50 years (Romme, 2003). I will use these two Klamath mountain regional distinctions as locations to asses the fires affect on forest succession, as well as the forests effects on the fires severity.

Whiskeytown National Recreation Area

The site for this study is the Whiskeytown national recreation area in California. The park covers an area of 42,500 acres of land, which is home to nearly 750 vascular plant species in a variety of different communities (U.S. National Park Service., 2008). Beginning on June 21st, 2008, the Whiskeytown national recreation area caught on fire during a lightning storm. This wildfire was separated into four different complexes throughout the park, burning a total of 6,240 acres, or 20 percent of the park by its end on July 15th, 2008 (U.S. National Park Service., 2008). Due to the fire's separation within the park, it managed to cover areas of different elevations and affect a variety of plant species.

In order to determine the effects the Whiskeytown fire complex had on plant diversity, I collected data in one low to mid montane region divided into both a burned and unburned environment. This specific isolated site is located within a valley created by Whiskey creek, a small stream that feeds directly into the reservoir named Whiskeytown Lake. On both sides of this creek the elevation sharply rises, ranging from 1,600 ft at the base to approximately 1,800 ft on either side. Despite the areas relatively low elevations for a mountainous region, its climate can be characterized as semiarid throughout most of the year. This region historically receives the majority of its precipitation during the winter months, specifically between an average of 4.03 inches in late November to an average of 5.15 inches in mid to late March. Throughout most of the year however this region receives on average little to no precipitation. Between the months of June and September this area receives on average a total of 1.44 inches, making up only 15 percent of the areas annual precipitation (RSS Weather). These occasional periods of summer precipitation within Whiskeytown occur generally as thundershowers. The lightning that comes along with these rare periods of summer precipitation is the main cause of the wildfires that occur in this region.

Despite this semiarid climate, the Whiskey creek valley manages to support a heavily vegetated landscape. However, this heavily vegetated region of the park had recently been seen as lacking the species diversity which this area is supposed to support. An area which has historically supported 170 exotic species making up 25 percent of the parks plants is now quite homogeneous, creating deterioration in the ecosystems health (Sarr, D., D. Odion, B. Truitt, E. Beever, S. Shafer, A. Duff, S. Smith, W. Bunn, J. Rocchio, E. Sarnat, J. Alexander, S. Jessup. 2004.). This major and concerning change in the species diversity is believed to be the cause of fire suppression efforts throughout the parks history. The removal of fire from a landscape such as Whiskeytown, where fire disturbance is part of the natural cycle has serious impacts. These impacts as seen in many areas of the park are the increases in tree density, late successional species, and surface organic matter buildup.

Because of the current ecological condition of the Whiskeytown National Recreation area at the time of the wildfire, many of the burned landscapes were bound to exhibit stark contrasts in their vegetative communities compared with those unaffected. It is this stark contrast that my project is based upon. By analyzing both the burned and unburned environments resulting from the 2008 Whiskeytown complex fires, the natural vegetative succession of the area could be determined, along with the influence the forests landscape had on the fires severity. The null hypothesis of my project was that the amount of post-burn plant diversity will be directly correlated with the areas level of fire severity. This direct correlation would then also dictate the level of forest succession found in this area. The alternative hypothesis was that no correlation will be found between fire severity and plant diversity, and thus any change in the level of forest succession could not be determined within the area.

Methods

The study began on May 12th, 2009 within the Whiskeytown national recreation area. Although the study was conducted as a solo effort, I was assisted greatly by the parks ecologist Jennifer Gibson and its supervisor Jim Milestone. Before beginning the trip out to Whiskeytown for this study I was required to submit an application for a collegiate research study. This included my thesis proposal, sampling intentions, duration of my study, as well as the supplies I was requesting from the park. Once this application had been approved by the parks ecology department and the park supervisor, I received a research permit valid for the duration of my four day study. On my arrival and at the outset of my study I was assisted in determining the most interesting and accessible locations available for my use. Although my original intention was to sample two different burned and unburned environments at different elevation regions, I was denied access to the 4,000 ft elevation region due to safety reasons. The projected mountain slope to be sampled, Shasta Bali, was deemed too dangerous for hiking because of the years late snow melt. However, I was directed towards an excellent location for my study of the areas low to mid montane elevation region, the Whiskey Creek valley.

I divided the Whiskey Creek valley into six sampling strips, three sampling strips on either side of a fire break ranging a distance of 1.2 miles between the burned and unburned areas. Each of these sampling strips contained five point-centered plots, distributed approximately 30 meters from each other covering a total sample area of 150 meters. Within each of these point-centered plots, one tree was selected as the center for which each plot was designated around. In each cardinal direction from each designated tree, four trees will be chosen that are in the closest proximity. For each of these trees chosen, its species, diameter at breast height, and distance between the sampling point and the tree was recorded. Also within these point-centered sampling plots, a 5 m by 5m sampling plot was designated where five measurements were taken on surface fuel load density. The last sampling plot within the point centered region was 1m by 1m where approximate percentages were used to determine the prevalence of grass, shrubs, saplings, moss/lichens, and bare mineral soil. In total, there were 60 point-centered plots designated for measurements and samples. By using this point-centered quarter method for collecting data, I was able to effectively analyze the fires effect on forest succession within the Whiskey Creek region of the park.

Results

After covering both the burned and unburned sides of the Whiskey Creek valley during May of 2009, a total of 8 tree species and 4 species of flowering plants were identified (Figure 1). Each side of the valley had its own species of prevalence. Within the unburned side of the valley, the California live oak was by far the most dominant, found at an average of 302.3 trees per hectare between 1,600 and 1,800 ft in elevation (Table 3). While on the burned side of the valley an entirely different situation was present. The most prevalent species found was the Scrub oak, a species completely absent from the unburned side of the valley. This interesting species of oak was found at an overwhelming average of 664.5 trees per hectare between 1,600 and 1,800 ft in elevation (Table 2). Despite the relative prevalence of these two species on their respective sides of the affected valley, the distribution of the other recorded species on the unburned side provided interesting insight into how the burned side of the valley had existed.

Ascending in elevation between 1,600 and 1,800 ft showed a definitive change in species composition within this area. Although the lower elevation level was overwhelmingly dominated by the Live Oak and Black Oak, the species richness of the area showed an increase along with the increase in elevation. The elevation region at

1,700 ft showed the emergence of Whiteleaf Manzanita, Douglas fir, and several species of long needle pines (Grey Pine, Ponderosa Pine, and Knobcone Pine) (Table 3). This species richness and diversity persisted and ultimately increased as the elevation increased up to 1,800 ft. This region at 1,800 ft showed a dramatic decrease in the population density of the Live Oak, along with a significant spike in the Whiteleaf Manzanita population (Table 3). Although the burned region of the valley did not exhibit near the level of species richness and diversity of the unburned side, the constant population density of both Whiteleaf Manzanita and long needle pine species (Grey Pine, Ponderosa Pine, and Knobcone Pine) show a possible parallel.

Along with the differences in species diversity and prevalence between the burned and unburned sides of the valley, the measurements taken on organic matter build-up and average ground cover in both locations showed stark differences. Within the burned region of the valley there was little to no organic matter present above bare mineral soil. Although the wildfire had occurred approximately 10 months prior, the re-sprouted vegetative species had not produced any significant level of leaf or pine needle litter. Throughout the elevation range of 1,600 ft to 1,800 ft, the average level of organic matter measured was 0.8 cm with little variation in the data set. Along with the levels of organic matter, the approximations taken on ground cover showed little variation throughout the elevation changes. The ground cover of the area consisted of equal divisions of exposed mineral soil, flowering plants, and cheat grass.

These relatively consistent levels of organic matter buildup and ground cover on the burned side of the valley were not the case on the unburned side. The measurements taken on organic matter build-up showed a decrease in height as the elevation of the area increased. Along the base of the valley at 1,600 ft, the height of organic matter measured had an average of 7.76 cm. With the increase in elevation up to 1,800 ft the average organic matter build-up decreased significantly down to 5.64. The approximations taken on ground cover in this area varied little with elevation, and consisted almost entirely of poison oak coverage.

Discussion

The results of this study on fires affect on forest succession and forests affect on fire severity had not been previously studied in this region of the park. This is primarily due to the fact that the Whiskeytown National Recreation Area had not been affected by widespread wildfires in almost 80 years (U.S. National Park Service., 2008). After analyzing the results from the study of both the burned and unburned sides of the Whiskey Creek valley, some interesting conclusions can be made about how the area was affected.

The current composition of the forest on the unburned side of the valley provided valuable information on how the entire area may have existed prior to the wildfire. Within this area the Live Oak was the most dominant in terms of species density, and showed significant changes as elevation increased. With this species of oaks density at 480.076 trees per hectare at 1,600 ft, and 388.764 trees per hectare at 1,700 ft, the dramatic decrease to 88 trees per hectare at 1,800 ft provides evidence of the type of environment this species is able to thrive in (Table 3). The Live Oaks dominance at lower elevations coincides with the fact that it is not a species known for drought tolerance (Carrington, M,. Keely, John,. 1999.). Thriving near the bottom of the valley where the soil holds the most moisture, it is not surprising the Live Oak struggles to exist in high densities at 1,800 ft where soil moisture is far more deficient. This fact also explains how as elevation in the valley increases, the species density of both Whiteleaf Manzanita and the long needle pines increased to concentrations above that of the Live Oak at 1,800 ft (Table 3). Both species are known to be more drought tolerant, and are able to thrive in the more moisture deficient soil conditions of the area (Carrington, M,. Keely, John,. 1999.).

Coinciding with the issue of soil moisture deficiency which regulates the elevation in which the California Live Oak is able to thrive, the changes in organic matter buildup with elevation may also play an important role in retaining soil moisture for this species. With the height of organic matter reaching 7.76cm at the elevation level of 1,600ft, this heavy covering would provide a substantial buffer for holding in the maximum amount of moisture. This may explain the ability of the California Live Oak at 1,600ft to thrive with such great density and sizeable trunk diameters averaging 1.2 m^2. Moving up in elevation to 1,800ft, the height of organic matter was reduced to an average of 5.64cm. This would theoretically reduce the amount of moisture the soil is able to retain and limit the Live Oaks population density, giving way to the more drought tolerant species of Whiteleaf Manzanita and long needle pines to thrive.

Along with the influence on soil moisture the changes in organic matter height have on elevation, these changes in organic matter height and California Live Oak density at 1,600 ft may have had an influence on the fire intensity on the burned side of the valley. Assuming the conditions studied on the unburned side of the valley roughly coincide with those prior to the wildfire on the burned side, this may explain some of the new ecological conditions found within the burned region. The emergence of the California Scrub Oak found throughout the elevation changes within this region raised the question as to how heavily the species relies on fire intensity to activate its dormant seed bank. Found at an incredibly high density of 1047.81 shrubs per hectare at 1,600ft, it confirms the fact that this particular species requires fires of relatively high intensity to re-sprout (Table 2). Considering the height of organic matter found at this elevation on the unburned side of the valley, this may have provided an environment of considerable fire intensity leading to the dramatic spike in the Scrub Oak population density (Tyler, Claudia., 1996.). This may also explain why the Scrub Oak was not found at near the population densities at the elevation levels of 1,700 and 1,800 feet (Table 2). With the decreased height of organic matter present in the higher elevations, the dormant Scrub Oak seeds may not have been exposed to the level of fire intensity required to produce the population density present at 1,600 ft (Keely, John., 1987). The reemergence of the Scrub Oaks high population density may also be due to its drought tolerance and adaptation to the region (Zedler, Paul,. Gautier, Clayton,. McMaster, Gregory,. 1983.). Found naturally within the Klamath Mountain region, this particular species could possibly be a key component to an earlier successionary state of the areas plant community.

This return of the Scrub Oak species to the burned region of the Whiskey Creek valley is not the only component of the new plant community that emerged. A dramatic alteration in ground cover involving the emergence of cheat grass and other flowering plants provided even further evidence of a return to an earlier successionary state (Zedler, Paul,. Gautier, Clayton,. McMaster, Gregory,. 1983.). These few species of newly emerged flowering plants can be collectively identified as "fire followers". The plants identified included the Fire Poppy (Papaver californicum), Fire Cracker (Russelia equisetiformis), and the Wild Hyacinth (Dichelsotemma capitatum). No real correlation between population density and elevation change could be determined with these species since they were found in various clusters throughout the region with varying densities. Like that of the Scrub Oak, the reemergence of these "fire follower" flower and grass species may be due to the activation of a dormant seed bank by the fires high intensity (Tyler, Claudia., 1996.). The return of these species dominance of the areas ground cover without the presence of Poison Oak is yet another indication of a return to an earlier successionary plant community.

The newly emerged plant community found on the burned side of the region may be drastically different then that of the unburned region, however, they do share parallels between Whiteleaf Manzanita and long needle pine population densities with elevation change. Both species are found at relatively similar population densities on both sides of the Whiskey Creek valley, ranging from 112.086 to 180.12 trees per hectare in the burned region and between 105.152 and 230.184 trees per hectare at 1,700 ft and 1,800 ft in the unburned region (Tables 2 & 3). This rough correlation shows both species to be well adapted to the area, and well established in both successions of plant communities within the Whiskey Creek valley.

The continued monitoring of species density and diversity in the post-fire environments of the Whiskeytown National Recreation Area will provide valuable information on the regions natural forest succession. This research would then further aid in better understanding the areas natural fire response, providing better land management techniques for the park.

Acknowledgements

This project was developed with the assistance of Dr. David Wedin who assisted me in developing the method of data collection I used during my study. My ability to conduct a study within the Whiskeytown National Recreation Area was entirely due to the help of Jennifer Gibson and Jim Milestone. Both were instrumental in approving my study within the park and giving me free access to campsites and materials throughout the duration of my stay there. This project was completed with the assistance of my thesis advisor John Quinn, and the continual patience and advice of Sara Yendra and Dave Gosselin. The project was also funded though the college of Natural Resources at the University of Nebraska.

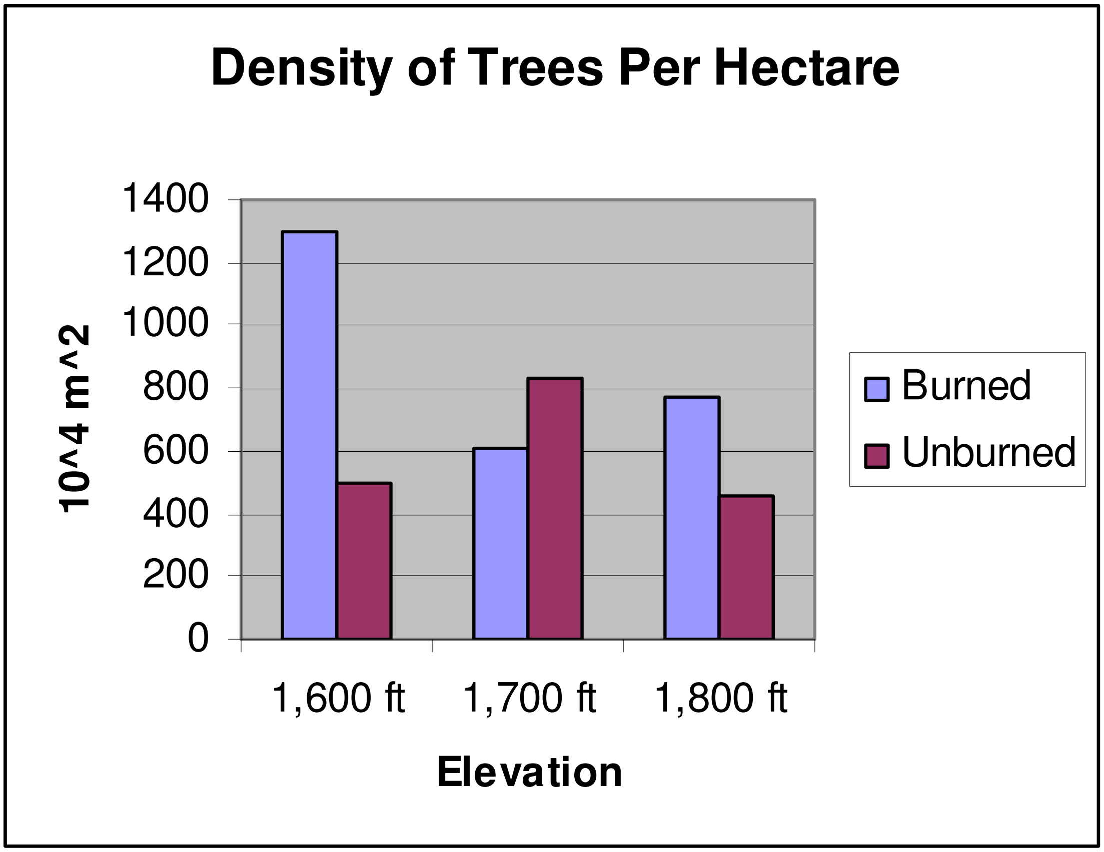

Density of Trees Per Hectare
1400
1200
1000
800
600
400
200
0
10^4 m^2
Burned
Unburned
1,600 ft
1,700 ft
1,800 ft
Elevation

Table 1

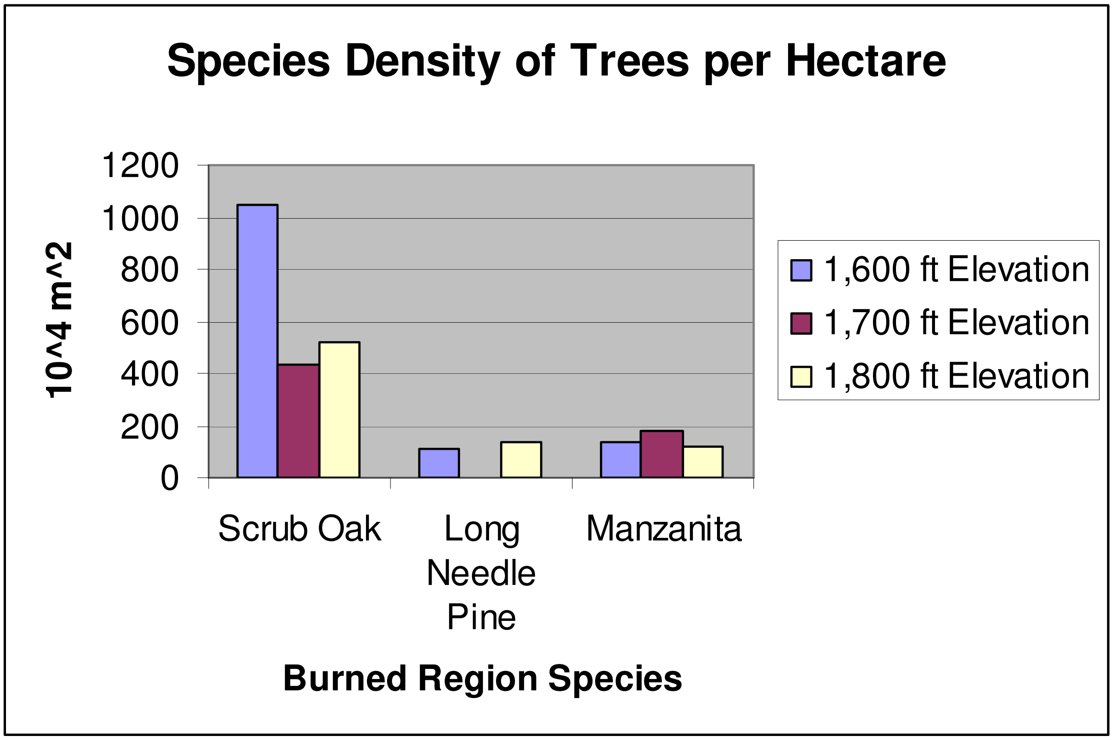


Table 2

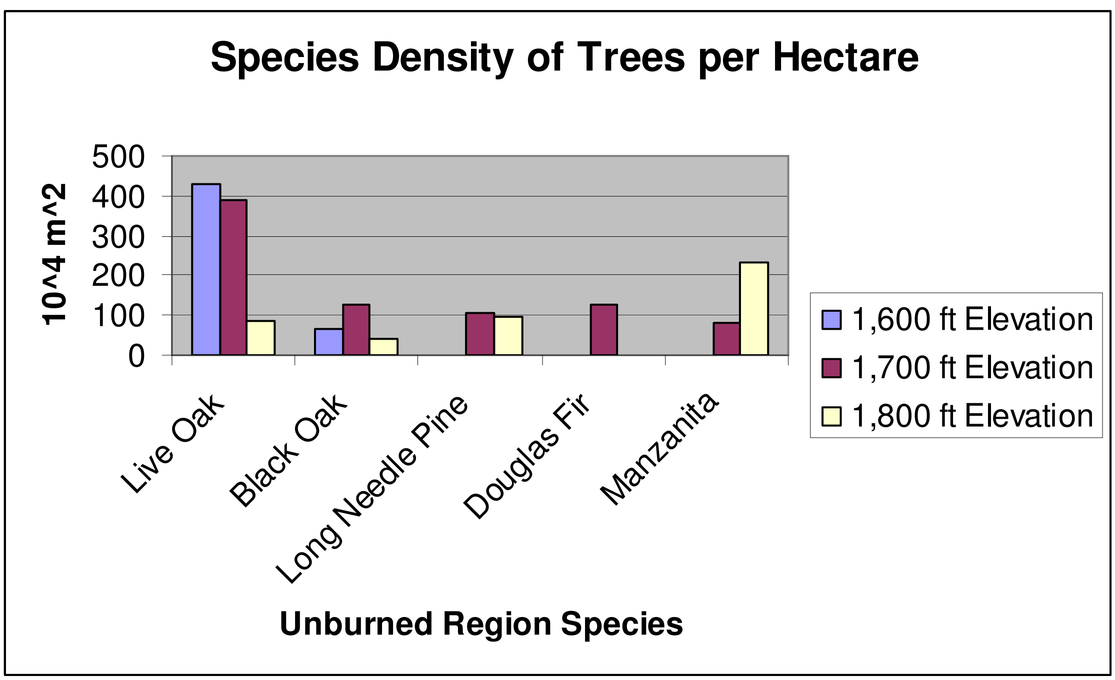
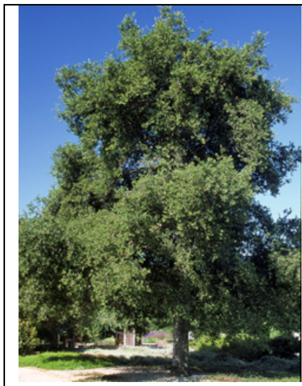
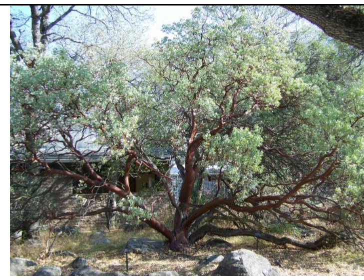
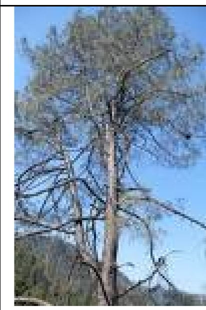


Table 3

<u>Identified Tree Species</u>

 California Live Oak-Quercus agrifolia	 Douglas Fir-Pseudotsuga menziesii	 Whiteleaf Manzanita-Arctostaphylos manzanita	 Scrub Oak-Quercus berberidifolia	
 California Black Oak-Quercus Kelloggii	 Knobcone Pine-Pinus attenuate	 Ponderosa Pine-Pinus ponderosa	 Grey Pine-Pinus sabiniana	

<u>Figure 1</u>

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